Food Preference of Seven Stored Product Insects to Dried Processed Taro Products[1]

E.B. JANG, C.S. LIN and W.C. MITCHELL[2]

INTRODUCTION

Renewed interest in the use of tropical root crops such as taro, cassava and sweet potato as high energy food sources has lead to improved technologies in their production, processing and storage. New methods in processing of taro (*Colocasia esculenta* L. schoot) has resulted in the development of dried taro products such as flour, rice, and noodles (Moy and Nip 1979). Although many countries are now initiating similar processing methods few have looked seriously at the potential damage to these products by stored product insects. Maddison (1979) listed a number of stored product insects found to attack dried cassava products. However no reports on taro products were mentioned. Preliminary observations on the susceptibility of various processed dried taro products to damage by stored product insects in this laboratory has shown that certain species are able to feed and reproduce on some of the taro products (unpublished observations). It was therefore of interest to investigate further the relationship between different processed taro products and their susceptibility to damage by stored product insect pests.

A variety of methods such as food preference (Loschiavo, 1952; 1959) growth and development (Chapman, 1924; Fraenkel and Blewett, 1943), oviposition (Good, 1936) and multiplication (Sinha, 1969, 1971; LeCato and McCray, 1973) have been reported in assessing the suitability of a particular food substance to stored product insects. The current study used food preference as the criterion for assessing the suitability of various processed taro products to seven species of stored product insects.

METHODS AND MATERIALS

Seven species of stored product insects (Table 1) commonly known to attack stored food products were tested against a variety of processed taro products. All insects were raised in the laboratory on the following food products *T. confusum* and *T. castaneum*, 95% whole wheat flour; and 5% brewers yeast; *S. oryzae* and *S. granarius* 50% white rice: and 50% whole wheat; *O. mercator*, whole rolled oats; *L. serricorne*, yellow cornmeal; *P. interpunctella*, whole wheat bran.

All tests were carried out in Loschaivo food preference chambers (LFPC) (Loschiavo, 1952). The circular chambers were constructed of plexiglass (6" diameter) and divided into 12 equal chambers. A small platform in the center

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[2]Department of Entomology, University of Hawaii, Honolulu, Hawaii 96822.

served as a nondirectional starting point for the insects. Each chamber contained ca 1 oz. of food and was allowed to stand at room temperatures for 24 h prior to introduction of the insects. Fifty insects were placed onto the center of each chamber and kept there for one hour prior to release. Chambers were kept in a dark oven at 28-30 °C and 65-70% RH during the test. Chambers were removed after three days and the insects present in each food fraction counted. A total of 18 taro products from two varieties were tested along with control products consisting of either whole wheat flour/yeast 95:5%, rolled oats, cornmeal, or rice/whole wheat 50:50% depending upon the insect species being tested. Taro products were randomly distributed in each of the test chambers. The tests were repeated four times for each insect tested. Adults and larvae were tested separately. Due to the large number of taro products which were screened, the products were divided into 2 groups (Group I and II) so that they could be tested in the LFPC. This resulted in some taro products being tested twice so that all 12 chambers would be filled in each test. Larvae of the two species of weevils were not tested for food preference. Also adults and larvae of the Indian meal moth were tested only on group I taro products.

All data was analyzed using the Duncan's multiple range test for analysis of variance and significance.

TABLE 1. Seven species of stored product insects which were tested for food preference to various processed taro products.

Common Name	*Scientific Name*
1. Cigarette beetle	*Lasioderma serricorne* (Fabricius)
2. Merchant grain beetle	*Oryzaephilus mercator* (Fauvel)
3. Confused flour beetle	*Tribolium confusum* Jacquelin du Val
4. Red flour beetle	*Tribolium castaneum* (Herbst)
5. Rice weevil	*Sitophilus oryzae* (Linnaeus)
6. Granary weevil	*Sitophilus granarius* (Linnaeus)
7. Indian meal moth	*Plodia interpunctella* (Hübner)

RESULTS

The results of the adult preference studies for group I and group II taro products are shown in Tables 2 and 3. Results of the larval preference studies are shown in Tables 3 and 4 respectively.

Cigarette beetle

Adult cigarette beetles did not show a clear preference for either the control (oats) or the taro products when tested in group I taro products. The highest percentage of adults were found in the oats followed by the white taro flour. Adults tested on group II taro products using a wheat flour/yeast control showed a slightly higher percentage on the thin enriched taro noodles than the other products. However, statistically there was no significant difference. Thin taro noodles and enriched taro rice were also well liked. Adults appeared to choose the coarse taro products and the finer milled products equally.

Cigarette beetle larvae showed a similar response to the adults in Group I and II taro products. The control (oats) was closely followed by the enriched flours (both Bun-long and Lehua variety) in group I products. Larvae showed the least preference among group II taro products.

Confused flour beetles and Red flour beetles

Adults of both *T. confusum* and *T. castaneum* showed a clear preference for the wheat flour/yeast controls over any of the taro products tested in both group I and II products. In each case over 50% of all the adults tested showed this preference. The most attractive taro products appeared to be the cooked taro flour (Group I) and the white taro flour and taro flour with raphides (Group II).

Larvae of the flour beetles showed little preference when tested on group I taro products. However, they clearly chose the control (wheat flour/yeast) in the group II taro products. Cooked poi appeared attractive to the confused flour beetle in group II tests.

Merchant grain beetle

Adult *O. mercator* preferred the control (oats) to the taro products in group I tests. There were no significant differences among the other products tested. In group II taro products using a wheat flour/yeast control the preference to the control product did not occur. Instead the insects showed a fairly random distribution in the chambers. Enriched taro rice contained the most insects followed by the white taro flours (both Bun-long and Apia variety) and the thin taro noodles. Larvae of *O. mercator* also showed a preference for the oats control when present (group II products) however did not show a clear choice when the wheat flour/yeast control was used.

Rice weevil and granary weevil

Both *S. oryzae* and *S. granarius* adults preferred the red taro noodles (variety Lehua) over any of the other taro products in the absence of a suitable control (rice/whole wheat) as shown in the Group I tests. When the flour control was replaced by the rice/whole wheat mixture (Group II taro products) it was clearly the food of choice in the adult rice weevil (mean of 54.6%). Adult granary weevils showed the highest percentage in the control mixture. However, statistically there were no differences between any of the group II products. Larvae of these species were not tested due to the fact that the lack of movement in the test chamber resulted in a high majority of the larvae staying in the center of the test chamber.

Indian meal moth

Adult *Plodia interpunctella* were found in greatest numbers in the sweet potato slices, red taro noodles and the paper (paper was used because of the lack of enough taro products in group I taro products). Unlike the coleopterans tested, *P. interpunctella* adults did not appear to move around in the chamber. However, adults were found in each of the sections of the chamber. *P. interpunctella* larvae showed lack of preference to any of the taro products. As is evident from Table 4, the larvae were more or less evenly distributed throughout the chambers.

DISCUSSION

Food preference is only a single criteria in assessing the suitability of stored product insects to various food fractions. Nonetheless it can be valuable in determining the probability that an insect will choose a particular food product. A majority of the insects tested in this study showed a preference towards the non-taro products in which they were raised. However in the absence of these products or when other non-taro products were used as controls, the insects often preferred certain taro products. Other factors such as particle size and nutritional values may also play an important role in food preference. Both species of flour beetles appeared to prefer the finer milled substances over the coarser products. This observation supports earlier reports by Oosthuizen (1945) and Loschiavo (1952) on food preferences in the flour beetles. On the other hand, both species of weevils *(S. granarius* and *S. oryzae)* appeared to choose the coarser products over the finely milled flours. Thus it appears that texture may play an important role in an insects choice of one product over another.

No differences were evident in the insect's choice of a particular variety of taro over another.

Given both non-taro and taro products it would appear from this study that the majority of stored product insects involved in this study would choose the non-taro products only if it happened to be a preferred product (one on which they have been raised). It is quite possible that the preference towards the control product is a conditioning response and given a suitable substrate, these insects could be conditioned to accept previously non-preferred foods (Loschiavo, 1952). The fact that taro products in some instances were chosen over the non-taro products suggests that these products are attractive as possible food sources and may be capable of sustaining insect growth and reproduction. Preliminary studies in this laboratory support this view. We have observed a number of species capable of reproduction in various dried taro and sweet potato products in the laboratory. More studies especially regarding growth and reproduction are needed to fully assess the potential of insect damage to taro products.

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TABLE 2. Adult preference of 7 species of stored product insects as shown by the mean percent of the total insects* visiting each product – Group I Taro Products.

TARO PRODUCTS	VARIETY	CIGARETTE BEETLE		CONFUSED FLOUR BEETLE		RED FLOUR BEETLE		MERCHANT GRAIN BEETLE	
Sweet Potato Slices		17.1	abc**	2.9	c	4.1	de	13.7	b
Red Taro Flour	Lehua	5.9	c	4.1	c	0.0	e	10.9	b
White Taro Flour	Bun-long	23.6	ab	4.9	c	0.0	e	10.1	b
Cooked Taro Flour	Bun-long	11.2	abc	24.1	b	17.1	b	9.8	b
Taro Slices	Bun-long	15.0	abc	4.1	c	2.9	de	8.8	b
Taro Flakes	Apia	6.1	c	6.1	c	13.8	bc	9.3	b
Red Taro Noodle	Lehua	8.2	bc	8.5	c	2.8	de	15.2	b
Taro Rice	Bun-long	12.5	abc	6.6	c	8.4	cd	9.3	b
Enriched Flour	Lehua	12.4	abc	10.8	c	0.0	e	7.0	b
Enriched Flour	Bun-long	14.4	abc	4.9	c	2.0	de	7.8	b
Paper		8.7	bc	6.6	c	0.0	e	14.4	b
Wheat Flour/Yeast 95:5%	Control			50.2	a	61.1	a		
Whole Rolled Oats	Control	26.6	a					44.3	a
LSD		18.3		10.2		6.4		7.6	

TABLE 2. (cont.)

TARO PRODUCTS	VARIETY	RICE WEEVIL	GRANARY WEEVIL	INDIAN MEAL MOTH
Sweet Potato Slices		21.4 b	13.2 cd	28.5 a
Red Taro Flour	Lehua	11.4 bc	2.1 e	9.9 bcd
White Taro Flour	Bun-long	2.7 c	3.8 de	7.7 cd
Cooked Taro Flour	Bun-long	4.1 c	8.5 cde	9.8 bcd
Taro Slices	Bun-long	6.0 c	16.7 bc	20.0 abc
Taro Flakes	Apia	0.0 c	2.7 e	6.4 d
Red Taro Noodle	Lehua	47.2 a	39.7 a	20.3 abc
Taro Rice	Bun-long	10.5 c	25.2 b	13.0 bcd
Enriched Flour	Lehua	2.1 c	11.5 cde	15.0 bcd
Enriched Flour	Bun-long	21.9 b	15.4 c	15.5 bcd
Paper		0.0 c	10.1 cde	21.2 ab
Wheat Flour/Yeast 95:5%	Control	4.7 c	8.1 cde	7.6 cd
LSD		9.4	8.1	12.5

*50 insects per treatment; 4 replications.
**Treatment means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

TABLE 3. Adult preference of 6 species of stored product insects as shown by the mean percent of the total insects* visiting each product – Group II Taro Products.

TARO PRODUCTS	VARIETY	CIGARETTE BEETLE		CONFUSED FLOUR BEETLE		RED FLOUR BEETLE		MERCHANT GRAIN BEETLE	
Sweet Potato Slices		15.4	abc**	0.0	d	4.1	cde	8.9	bcd
Red Taro Flour	Lehua	12.9	abc	2.2	cd	4.2	cde	3.8	dc
White Taro Flour	Bun-long	5.3	c	16.3	b	0.0	e	16.6	abc
Cooked Taro Flour	Bun-long	8.7	bc	2.9	cd	5.8	bcde	13.2	bcd
Cooked Poi	Lehua	9.0	bc	2.0	cd	2.0	de	3.2	d
Thin Taro Noodle	Bun-long	20.8	ab	2.0	cd	5.1	bcde	12.7	bcd
Thin Enriched Taro Noodle	Bun-long	25.9	a	13.0	bc	2.0	de	17.9	ab
Enriched Rice	Bun-long	16.0	abc	13.2	bcd	13.6	bc	28.2	a
Taro Flour w/Raphides	Apia	14.4	abc	6.2	bcd	16.2	b	12.2	bcd
Taro Flour w/o Raphides	Apia	12.6	abc	11.2	bcd	6.4	bcde	8.4	bcd
White Taro Flour	Apia	7.6	bc	4.2	bcd	12.8	bcd	17.5	ab
Wheat Flour/Yeast 95:5%	Control	14.3	abc	51.8	a	54.8	a	9.2	bcd
LSD		15.6		10.6		9.2		12.6	

TABLE 3. (cont.)

TARO PRODUCTS	VARIETY	RICE WEEVIL	GRANARY WEEVIL
Sweet Potato Slices		6.0 b	13.7 a
Red Taro Flour	Lehua	8.5 b	8.7 a
White Taro Flour	Bun-long	7.7 b	15.9 a
Cooked Taro Flour	Bun-long	6.1 b	14.8 a
Cooked Poi	Lehua	7.4 b	14.9 a
Thin Taro Noodle	Bun-long	12.4 b	15.8 a
Thin Enriched Taro Noodle	Bun-long	12.2 b	8.1 a
Enriched Rice	Bun-long	10.0 b	10.0 a
Taro Flour w/Raphides	Apia	6.6 b	18.3 a
Taro Flour w/o Raphides	Apia	8.5 b	12.2 a
White Taro Flour	Apia	0.0 b	8.5 a
Rice/Whole Wheat 50:50%	Control	54.6 a	25.4 a
LSD		10.3	18.8

*50 Insects per treatment; 4 replications.
**Treatment means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

TABLE 4. Larval preference of 5 species of stored product insects as shown by the mean percent of the total larvae* visiting each product – Group I Taro Products.

TARO PRODUCTS	VARIETY	CIGARETTE BEETLE		MERCHANT GRAIN BEETLE		CONFUSED FLOUR BEETLE		RED FLOUR BEETLE		INDIAN MEAL MOTH	
Sweet Potato Slices		2.8	c**	11.7	cde	13.5	ab	18.5	abc	15.1	bc
Red Taro Flour	Lehua	15.4	abc	7.2	de	11.3	b	8.3	c	7.3	cd
White Taro Flour	Bun-long	10.4	bc	6.0	e	9.6	b	11.7	bc	18.9	abc
Cooked Taro Flour	Bun-long	8.9	bc	6.9	de	19.4	ab	13.3	bc	7.3	cd
Taro Slices	Bun-long	2.7	c	16.2	bcd	19.8	ab	19.6	ab	11.3	bcd
Taro Flakes	Apia	17.5	abc	24.0	ab	13.5	ab	16.3	abc	15.9	bc
Red Taro Noodle	Lehua	4.5	c	13.8	cde	12.9	ab	18.8	ab	20.2	ab
Taro Rice	Bun-long	4.5	c	18.8	abc	10.7	b	24.1	a	14.5	bc
Enriched Flour	Lehua	19.4	abc	15.1	bcde	17.6	ab	14.4	abc	20.5	ab
Enriched Flour	Bun-long	25.1	ab	5.9	e	16.1	ab	12.3	bc	11.0	bcd
Paper		6.0	c	26.0	a	9.0	b	10.8	bc	2.2	d
Wheat Flour/Yeast 95:5%	Control			20.8	abc	27.0	a	18.0	abc		
Whole Rolled Oats	Control	29.6	a							29.0	a
LSD		17.9		8.7		18.1		11.2		11.3	

*50 larvae per treatment; 4 replications.

**Treatment means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

TABLE 5. Larval preference of 4 species of stored product insects as shown by the mean percent of the total larvae* visiting each product – Group II Taro Products.

TARO PRODUCTS	VARIETY	CIGARETTE BEETLE		MERCHANT GRAIN BEETLE		CONFUSED FLOUR BEETLE		RED FLOUR BEETLE	
Sweet Potato Slices		7.6	de**	6.6	bc	2.1	f	0.0	e
Red Taro Flour	Lehua	14.2	abcd	11.3	bc	17.8	bc	15.7	b
White Taro Flour	Bun-long	16.9	abcd	4.9	c	12.6	cde	11.4	bcd
Cooked Taro Flour	Bun-long	21.8	ab	5.6	c	11.6	cde	8.8	bcde
Cooked Poi	Lehua	19.3	abc	13.1	bc	23.5	b	14.9	b
Thin Taro Noodle	Bun-long	12.2	cd	9.1	bc	2.1	f	2.1	de
Thin Enriched Taro Noodle	Bun-long	14.5	abcd	16.7	b	7.1	def	6.5	bcde
Enriched Taro Rice	Bun-long	18.9	abc	6.1	bc	4.2	ef	7.1	bcde
Taro Flour w/Raphides	Apia	16.4	abcd	5.5	c	14.9	cd	13.5	bc
Taro Flour w/o Raphides	Apia	0.0	e	10.7	bc	9.4	cdef	4.9	cde
White Taro Flour	Apia	13.2	bcd	11.2	bc	14.5	cd	15.8	b
Wheat Flour/Yeast 95:5%	Control					40.6	a	48.3	a
Whole Rolled Oats	Control	23.3	a	50.9	a				
LSD		8.4		8.5		7.2		7.8	

*50 larvae per treatment; 4 replications.
**Treatment means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.